Upper Bulkley floodplain habitat: modifications, physical barriers, and sites of potential importance to salmonids

Final Report

Upper Bulkley floodplain habitat: modifications, physical barriers, and sites of potential importance to salmonids – Final Report

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For Fisheries and Oceans Canada

Cover photo: Upper Bulkley River, October 2013. Brian Huntington.

SkeenaWild Conservation Trust is a regionally based organization. We are dedicated to bringing together governments, First Nations and members of the public in the Skeena Watershed to sustain the long-term health and resilience of the wild salmon ecosystem, while optimizing economic returns to First Nations and local communities.

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Introduction

The Bulkley River upstream of Morice River has some of the most intense public and private land use in the Skeena watershed. Habitat has undergone considerable modification since the early 1900s, and a variety of environmental impacts persist. Transportation infrastructure development (railway and impermeable roads), forest removal, and agriculture-related erosion and nutrient inputs continue to diminish habitat and associated water quality of the Upper Bulkley River, Bulkley Lake, and Maxan Lake. These primary water bodies are important habitat for salmonids, and an assessment of habitat modifications is essential to the development of recovery plans for fish currently of conservation concern in this region, such as sockeye salmon (*Oncorhynchus nerka*).

The purpose of the assessment was to document human-induced modifications to floodplain habitat and river channelization, investigate potential barriers to fish migration, and to assess areas of upwelling groundwater in the Upper Bulkley mainstem having potential importance to salmonids. During two helicopter flights, the Upper Bulkley floodplain upstream of Morice River to the headwaters at Maxan Lake was assessed for modifications to habitat, as well as potential locations of ground water intrusion that may be important to salmon. Thus, this report is divided into two sections based on each flight: habitat concerns and sites of ground water influence. Relevant background information on specific water quality and flow issues is included in the habitat concern section with detailed information on the current state of sockeye in the Upper Bulkley, and the report concludes with recommendations for improved information.

1. Habitat concerns

During a single helicopter flight of two-hour duration on October 28, 2013, continuous video footage of the Upper Bulkley River floodplain was recorded on the upstream leg from the Morice River confluence to the headwaters at Maxan Lake, and specific habitat modifications and barriers were recorded by still photography and video during return travel (see: Upper_Bulkley_Flight_28Oct13.kml file for full details of flight path and waypoints of interest). A total of 131 separate habitat concerns were observed and recorded in 719 photographs; images provided on Disk-1. Modifications to habitat associated with transportation infrastructure (railway and roads, which include crossings; 50) were the most frequently observed habitat concern, followed by riparian habitat loss (41), beaver activity (29), log-jam (10), cattle on river bank (2), and land slide (1).

Railway and road infrastructure

Modifications to habitat associated with transportation infrastructure (primarily rail) were the most frequently observed habitat concern (Table 1). The Grand Trunk Pacific Railway (now CN Rail) construction was completed through the Bulkley Valley in 1914. The railway encroachment runs the length of the valley bottom, at times directly adjacent to the Upper Bulkley River and Bulkley Lake with 17 crossings of the mainstem.. Channel lateral movement is often constrained by the rail line (Figure 1). Impacts include riparian habitat loss, confinement and encroachment of the river channel by the rail line,

Table 1. Transportation infrastructure recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, during a helicopter flight on October 28, 2013. Waypoint number refers to locations plotted in: Upper_Bulkley_Flight_28Oct13.kml.

Waypoint number	Photo series	Easting	Northing	Notes
75	UB-257	686614	6023770	Road crossing
88	UB-315 to 321	685549	6028826	Derelict bridge
94	UB-342 to 356	685785	6030439	Strombould's rail/road crossings
95	UB-357 to 362	685310	6030510	Rip-rap
97	UB-366 to 369	684926	6031060	Rip-rap
100	UB-384 to 388	683685	6032076	Bridge
101	UB-389 to 395	683002	6032245	Rail bridge
102	UB-396 to 402	682505	6032418	Rail impediment
103	UB-403 to 405	682091	6032534	Bridge crossing
104	UB-406 to 410	681888	6032762	Bridge crossing
110	UB-419 to 424	681055	6035312	Bridge crossing
112	UB-426 to 427	681042	6036271	Rail/rip-rap
114	UB-431 to 434	680310	6037029	Bridge
116	UB-441 to 444	679961	6037252	Bridge and new track
118	UB-446 to 448	679148	6037507	Rail to river
129	UB-476 to 479	677763	6040152	Rail crossing
130	UB-480 to 486	677719	6040526	Rip-rap
132	UB-489 to 492	677292	6040997	Rail crossing
134	UB-494 to 496	676801	6041386	Rip-rap
135	UB-497 to 501	676547	6041728	Rail to river
136	UB-502 to 507	676358	6042030	Rail to river
142	UB-523	673931	6043020	Rail to river
144	UB-527 to 532b	673142	6043205	Rail impediment
147	UB-537 to 538	672098	6043368	Rail bridge/richfield
151	UB-546 to 548	670206	6043943	Rail bridge
155	UB-562 to 563	669392	6043980	Rail to river
156	UB-564 to 566	668935	6043858	Rip-rap and rail impediment
159	UB-571 to 576	667876	6044164	Rail bridge
160	UB-577 to 580	667599	6043901	Rail to river
170	UB-609 to 610	663942	6043256	Rail impediment
171	UB-611 to 612	663396	6042264	Rail impediment
172	UB-613 to 616	662962	6041236	Rail impediment
180	UB-634 to 639	661181	6038563	Rail impediment
183	UB-646 to 649	660929	6037901	Rail impediment
184		660629	6037716	Rail impediment
190	UB-660 to 662	659600	6036720	Rail impediment
191	UB-663	659158	6036486	Rail impediment
193	UB-668	658767	6036267	Rail impediment
194	UB-669 to 671	658629	6036169	Rail impediment
196	UB-673	658300	6035785	Bridge crossing
197	UB-674	656975	6035591	Rail impediment
198	UB-675 to 677	656590	6035193	Rail impediment
199	UB-678 to 683	656233	6034772	Rail impediment
200	UB-684 to 687	655751	6034399	Rail impediment
205	UB-695 to 698	653873	6031629	Road impediment
206	UB-699 to 704	653536	6031438	Bridge, road impediment
207	UB-705 to 706	653033	6031247	Houston bridge
208	UB-707 to 708	652529	6031048	Houston rip-rap
209	UB-709 to 712	651559	6030710	Houston rip-rap
212	UB-717 to 719	650701	6029641	Rail rip-rap

Figures 1 and 2. Confinement of the Upper Bulkley River due to railway infrastructure (top), and use of rip-rap to stabilize "Forestdale" road on the Upper Bulkley River 2km downstream of Bulkley Lake (bottom), October 2013. Photos: Brian Huntington.

increased sediment delivery, loss of floodplain connectivity, and increased peak flows. The ongoing periodic removal of large logjams by CNR removes key elements of water and sediment storage and energy dissipation, decreases channel complexity, and directly contributes to the loss of fish habitat as the channel becomes more incised and disconnected from the floodplain. Highway 16 also traverses the length of the Upper Bulkley River, with similar associated impacts to riparian habitat and floodplain functioning. All habitat modifications observed involve the use of rip-rap (Figure 2).

Riparian habitat loss

Riparian habitat loss was most frequently associated with forest removal and agriculture (Table 2). Two forms of employment for early settlers were land clearing for agriculture and tie-making for the railway. The hewn tie industry flourished through the 1920s and 1930s because of the large stands of lodgepole pine in the Upper Bulkley. Ties were typically hauled-out of forests by horse teams and sleighs along snow-covered winter roads, then towed to the foot of Bulkley Lake and floated one mile down the Bulkley River to the railway siding. The area between Houston and Burns Lake produced more hewn ties than any comparable section along the railway (Mould 1976), with the south side of Bulkley Lake producing particularly large volumes.

Logging in the Upper Bulkley transitioned from small-scale selective and strip logging to clear-cut logging in the late 1960s. The Northwood Pulp and Timber mill in Houston was the largest sawmill in the world when operations began in 1970. Sediment inputs from roads, and blockage of fish habitat from poor culvert installations, were the primary impacts to streams from the extensive logging.

Regarding agriculture, five ranches and 20 hobby farms running approximately 500 breeding cows were operating in the Upper Bulkley as of 1996 (Remington and Donas 2001); however, this number currently needs to be substantiated. Hayfields commonly extend to the bank of the Bulkley River (Figure 3), and much of the non-native grains and grasses have replaced native low-lying riparian vegetation occurred. Finally, two separate herds of cattle were recorded on the bank of the Bulkley River during the observation flight (Figure 4).

Table 2. Riparian habitat loss recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, during a helicopter flight on October 28, 2013. Waypoint number refers to locations plotted in: Upper_Bulkley_Flight_28Oct13.kml.

Waypoint number	Photo series	Easting	Northing	Notes
76	UB-258	686210	6024130	Field to river
78	UB-262 to 264	685237	6024844	Field to river
82	UB-283 to 285	683917	6027487	Hay field
84	UB-291 to 299	684354	6028189	Hay field
90	UB-325 to 327	685789	6029396	Field to river
91	UB-328 to 334	686037	6029429	Field to river
96	UB-363 to 365	685110	6030621	Field to river
98	UB-370 to 372	684495	6031282	Field to river
99	UB-373 to 383	684008	6031695	Field to river
100	UB-384 to 388	683685	6032076	Hay field
111	UB-425	681362	6035812	Hayfield/power line
113	UB-428 to 430	680861	6036661	Field to river
125	UB-467	677952	6039499	Hay field
131	UB-487 to 488	677614	6040916	Field to river
138	UB-510 to 511	675177	6042050	Field to river
139	UB-512	674850	6042113	Cattle farm to river
140	UB-513 to 515	674572	6042590	Field to river
143	UB-524 to 526	673672	6043081	Field to river
145	UB-533 to 534	671960	6043267	Ploughed field to river
148	UB 539	672217	6043636	Homested on river bank
157	UB-567 to 568	668718	6044141	Field to river
158	UB-569 to 570	668132	6044225	Field to river
161	UB-581 to 584	666827	6043710	Field to river
162	UB-585 to 586	666637	6044012	Field to river
168	UB-598 to 600	665013	6043738	Field to river
173	UB-617 to 623	662763	6040601	Field to river
175	UB-626 to 627	663203	6039849	Field to river
176	UB-628 to 630	662888	6039572	Cattle on river bank
177	UB-631	662554	6038924	Field to river
178	UB-632	661935	6038530	Field to river
179	UB-633	661750	6038638	Field to river
181	UB-640 to 642	661220	6038243	Field to river
182	UB-643 to 645 [UB-645b]	661095	6037670	Field to river
185	UB-650 to 651	660804	6037542	Field to river
186	UB-652 to 653	660186	6037094	Field to river/new felling
188	UB-655	660025	6036894	Field to river
192	UB-664 to 667	658950	6036296	Field to river
195	UB-672	658302	6035960	Field to river/new felling
203	UB-690 to 692	654578	6032198	Field to river
204	UB-693 to 694	654145	6032016	Field to river
205	UB-695 to 698	653873	6031629	Cattle on river bank

Figures 3 and 4. Hayfield extending to the bank of the Upper Bulkley River (top), and cattle on the river bar (bottom), October 2013. Photos: Brian Huntington.

Beaver activity

Beaver dams have long been cited as a potential barrier to adult salmon migration along the Upper Bulkley River. Of the 27 beaver dams observed (Table 3), 5 were located between Maxan Lake and Bulkley Lake (Figure 5), and 21 beaver dams were observed between Bulkley Lake and Houston (with 9 dams situated between Houston and Bulkley Falls). Eight of the beaver dams appear to have be breached, and may not constitute a physical barrier to salmon (Figure 6); though the release of an aging beaver impoundment may send a debris torrent downstream.

Table 3. Beaver activity recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, during a helicopter flight on October 28, 2013. Waypoint number refers to locations plotted in: Upper_Bulkley_Flight_28Oct13.kml.

Waypoint number	Photo series	Easting	Northing	Notes
77	UB-259 to 261	685466	6024649	Dam
79	UB-265 to 270	684348	6024997	Dam
80	UB-271 to 274	683932	6026032	Dam
83	UB-286 to 290	684190	6027906	Activity
85	UB-300 to 304	684890	6028667	Activity
86	UB-305 to 307	685106	6028665	Dam
87	UB-308 to 314	685428	6028712	Dam
89	UB-322 to 324	685814	6029114	Dam
99	UB-373 to 383	684008	6031695	Dam
105	UB-411 to 412	681419	6033019	Dam
106	UB-413 to 415	681137	6033505	Dam
107	UB-416	681166	6033765	Dam
108	UB-417	680743	6034552	Dam
109	UB-418	680933	6034871	Dam
110	UB-419 to 424	681055	6035312	Dam
115	UB-435 to 440	679974	6037284	Dam
117	UB-445	679540	6037279	Dam
118	UB-446 to 448	679148	6037507	Dam
119	UB-449 to 453	679010	6037815	Dam
120	UB-454 to 455	678774	6038004	Dam
122	UB-460 to 462	678222	6038509	Dam
124	UB-465 to 466	678104	6039025	Dam
126	UB-468 to 471	677719	6039669	Dam
127	UB-472	677666	6039852	Dam
128	UB-473 to 475	677550	6039878	Dam
130	UB-480 to 486	677719	6040526	Dam
133	UB-493	676911	6041236	Dam
134	UB-494 to 496	676801	6041386	Dam
189	UB-656 to 659	659727	6036905	Dam

Figures 5 and 6. Beaver activity - intact dam (top), and breached dam (bottom) - recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, October 2013. Photos: Brian Huntington.

Log-jam and landslide

While large woody debris (such as in log-jams) is an important component of riverine systems for sediment storage, energy dissipation, channel complexity, and deep pools for salmon, they can also serve as a potential barrier to migrating adults when disproportionately large and/or numerous. A total of 9 locations were identified for the presence of large log-jams during our assessment (Table 4; Figure 7). All but one of the log-jams were located downstream of Bulkley Lake, and any one of them may serve as a potential barrier to salmon. Additionally, a single landslide was observed along Maxan Creek (Figure 8).

Table 4. Large log-jams and a landslide recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, during a helicopter flight on October 28, 2013. Waypoint number refers to locations plotted in: Upper_Bulkley_Flight_28Oct13.kml.

Waypoint number	Photo series	Easting	Northing	Notes
78	UB-262 to 264	685237	6024844	Log-jam
81	UB-275 to 282	683762	6026942	Landslide
82	UB-283 to 285	683917	6027487	Log-jam
123	UB-463 to 464	678184	6038767	Log-jam
154	UB-559 to 561	669614	6044178	Log-jam
174	UB-624 to 625	662902	6040258	Log-jam
187	UB-654	659934	6037048	Log-jam
200	UB-684 to 687	655751	6034399	Log-jam
201	UB-688	655269	6033756	Log-jam
202	UB-689	655385	6033514	Log-jam

Figures 7 and 8. Log-jam (top) and landslide (bottom) recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, October 2013. Photos: Brian Huntington.

Water Quality Concerns

Excess nutrients

The Upper Bulkley catchment is considered at "high-risk" because of easily erodible phosphorus-rich soils. Mining, forestry, and agriculture have exacerbated the addition of phosphorus to the aquatic environment through chronic sedimentation, and accelerated downstream transport of sediments through changes of run-off regime and alterations to channel morphology.

Ambient phosphorus concentrations in Foxy/Maxan Creeks are currently sufficient to saturate algal growth requirements for that nutrient; thus, any input of nitrogen from land-use activities (such as discharge from Equity Silver, and agriculture) will likely result in an increase in algal biomass. Foxy Creek receives nitrogen-rich treated water discharges during high stream-flows, and possibly groundwater seepages year-round, from the Equity Silver mine-site. During treated water discharge, mean dissolved inorganic nitrogen (DIN) concentration has averaged 322 µg/L; excluding periods of treated water discharge, Foxy Creek mean DIN concentration has been 54 µg/L (Remington and Donas 2001); however, these concentrations currently need to be substantiated.

Bulkley Lake is considered "eutrophic" (Wetzel 1983; Reckhow and Simpson 1980; Remington and Donas 2001). The concentration of total phosphorus in Bulkley Lake during 1985-1987 ranged 13 µg/L to 475 µg/L ($\overline{x}$ = 90.6 µg/L), and total phosphorus during spring overturn over the same period ranged 32 µg/L to 37 µg/L ($\overline{x}$ = 34.5 µg/L; Remington and Donas 2001). The BC provincial water quality guideline for spring overturn total phosphorus is 5-15 µg/L for lakes supporting salmonids (Nordin 1985). However, current concentrations need to assessed.

Several aspects of cattle ranching can affect surface or ground water. The following have been documented by Provincial audits by the Ministry of Agriculture, Fisheries, and Food (1993): improper burial of dead animals (27% of operations audited), release of silage effluent and wasted feed (27%), improper manure handling or storage (36%), yard run-off from outdoor cattle pens in proximity of watercourses (91%), improper cattle watering facilities with direct access to water courses (50%), and leachate production from sawdust storage (25%; Remington and Donas 2001). Important to know whether cattle ranching practices have improved, and how the above infractions influence water quality in the Upper Bulkley.

Temperature

Elevated water temperatures (18-20°C) were recorded in the Upper Bulkley River downstream of Bulkley Lake outlet in late June and mid-August 1998, which suggests that these temperatures may have remained at high levels during the period when salmon (and particularly, sockeye) are expected to migrate through (Remington and Donas 2001). These temperatures equal or exceed the maximum weekly BC water quality guideline for salmonids. Dissolved oxygen concentrations were also near or below the Bulkley River objective of 7.8 mg/L (minimum) in June 1998; an inverse relationship exists between dissolved oxygen concentrations and stream temperature, such that an increase in stream temperature will decrease the concentration of dissolved oxygen.

Contaminants of potential concern

The Equity Silver metal mine, which began operations in 1980, and stopped production in 1994, is located in the headwaters of Foxy Creek (tributary to Maxan Creek) and Buck Creek (tributary to Bulkley River). Mining of metals and road building removed vegetation in the headwaters of Foxy and Buck Creeks, which likely contributed to sedimentation downstream. Acid rock drainage (ARD) is occurring at this mine site, and has the potential to continue for decades to centuries. A primary effect of ARD is that the acid generated can dissolve metals (including arsenic, cadmium, copper, zinc, and others) into solution, and metal-laden drainage waters can be lethal to aquatic biota, including salmon. Within a few years of mine start-up, elevated levels of acidity, copper, iron, and zinc were found in seepages from tailings ponds adjacent to Foxy Creek. Excess tailings pond supernatant, treated mine drainage, and treated sewage from the diversion pond is released directly to Foxy Creek. Permitted discharges of water must be equivalent to or better than the following for pH and metal concentrations:

pH (6.5-9.0)
Dissolved aluminum (50 mg/L)
Dissolved cadmium (10.0 µg/L)
Dissolved copper (50.0 µg/L)
Dissolved zinc (200 µg/L)

Dissolved copper concentrations in Foxy Creek have been declining since 1980 (Figure 9), with average levels in 2012 far below permitted discharge levels (Table 5). However, average dissolved copper levels in Foxy Creek downstream of the discharge site ($\bar{x}$ = 3.46 µg/L) were significantly higher than upstream sites ($\bar{x}$ = 1.64 µg/L; t = 2.6017, df = 37, p = 0.013) during the period 1980-2012. Furthermore, maximum copper concentrations have exceeded levels known to cause direct and indirect mortality (Hansen et al. 2002; McIntyre et al. 2012) at the downstream site in Foxy Creek in more than 50% of years. While cadmium also has been reported in higher concentrations downstream of the Equity discharge site, maximum levels known to cause sub-lethal effects in salmonids (Scott et al. 2003) have only been recorded in two years (1991 and 2002).

Between 1972 and 1982, copper sulphide concentrates from Noranda's Bell and Granisle Mines (of Babine Lake) were stored at two transfer stations adjacent to the Upper Bulkley River near Topley. While these concentrates apparently contaminated large volumes of riparian soils, a study by Morin and Hutt (2000a, 2000b) concluded that water quality and associated aquatic life were receiving insignificant impacts (Gottesfeld and Rabnett 2008). It seems important that this location be re-assessed to ensure it is no longer a habitat concern.

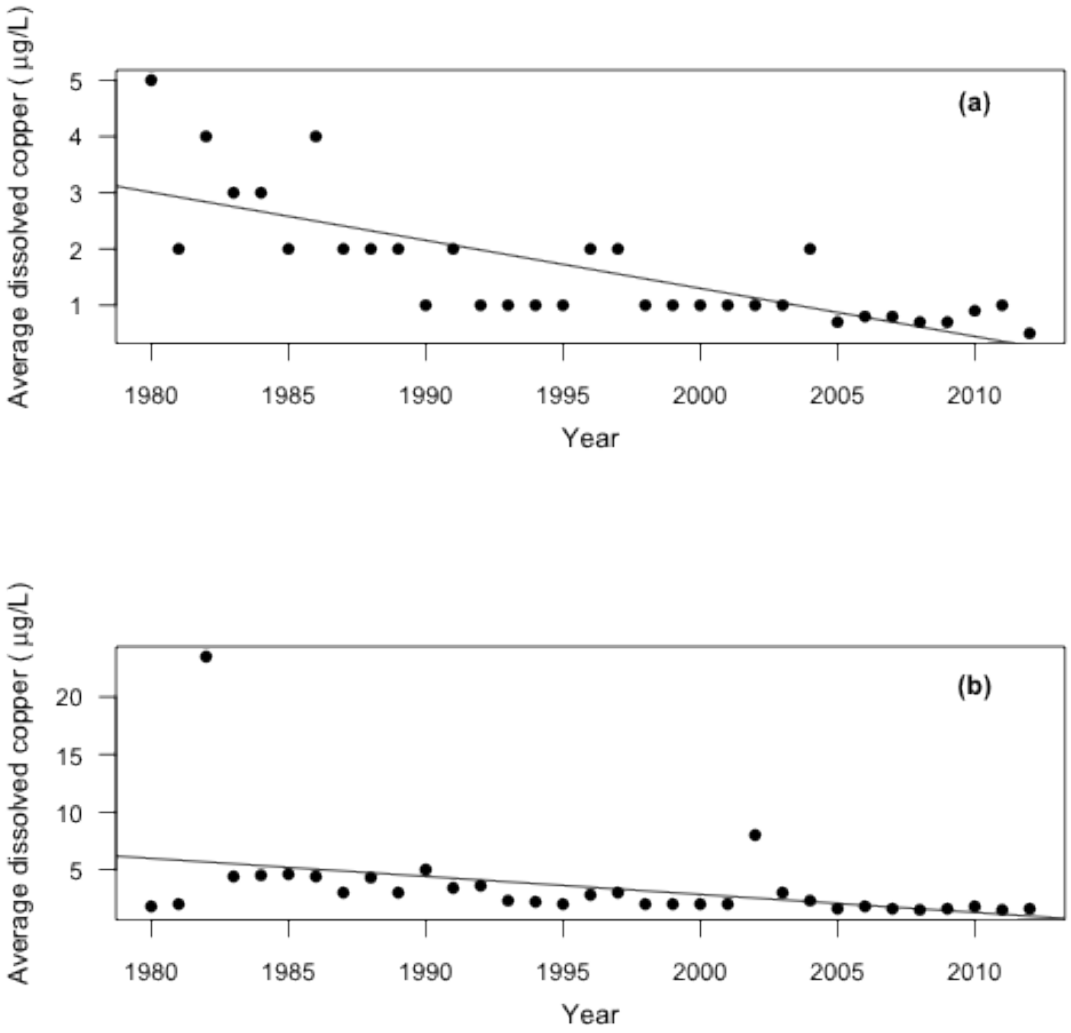

Figure 9. Average dissolved copper concentrations in Foxy Creek at locations above (a) and below (b) Equity Silver mine discharge site recorded during 1980-2012. Note: y-axis scales are different between the two sites.

Table 5. Average and maximum dissolved copper (Cu) and cadmium (Cd) concentrations (µg/L) in Foxy Creek at locations above (Upper) and below (Lower) Equity Silver mine discharge site recorded during 1980-2012.

	Upper Foxy Creek				Lower Foxy Creek			
Year	Average Cu	Maximum Cu	Average Cd	Maximum Cd	Average Cu	Maximum Cu	Average Cd	Maximum Cd
1980	5.0	22.0	-	-	1.8	3.0	-	-
1981	2.0	8.0	-	-	2.0	5.0	-	-
1982	4.0	36.0	-	-	23.5	180.0	-	-
1983	3.0	8.0	0.500	0.500	4.4	18.0	0.500	0.500
1984	3.0	8.0	0.600	1.000	4.5	13.0	0.670	1.000
1985	2.0	8.0	0.500	0.200	4.6	9.0	0.500	0.500
1986	4.0	14.0	-	-	4.4	15.0	0.500	0.500
1987	2.0	4.0	-	-	3.0	6.0	0.500	0.500
1988	2.0	8.0	-	-	4.3	12.0	0.230	0.500
1989	2.0	5.0	0.200	0.200	3.0	7.0	0.210	0.300
1990	1.0	2.0	1.000	1.000	5.0	17.0	0.220	0.400
1991	2.0	9.0	-	-	3.4	7.0	0.510	3.700
1992	1.0	4.0	-	-	3.6	8.0	0.210	0.300
1993	1.0	2.0	-	-	2.3	8.0	0.200	0.200
1994	1.0	2.0	0.200	0.200	2.2	5.0	0.200	0.200
1995	1.0	4.0	0.200	0.200	2.0	5.0	0.200	0.200
1996	2.0	4.0	0.200	0.200	2.8	5.0	0.200	0.200
1997	2.0	4.0	0.100	0.100	3.0	6.0	0.100	0.300
1998	1.0	2.0	0.100	0.100	2.0	4.0	0.100	0.200
1999	1.0	4.0	0.100	0.100	2.0	5.0	0.100	0.300
2000	1.0	2.0	0.100	0.100	2.0	7.0	0.200	0.600
2001	1.0	2.0	0.100	0.100	2.0	5.0	0.200	0.600
2002	1.0	2.0	0.100	0.300	8.0	80.0	0.200	2.100
2003	1.0	2.0	0.100	0.200	3.0	4.0	0.200	0.800
2004	2.0	6.0	0.100	0.100	2.3	3.9	0.110	0.240
2005	0.7	1.0	0.100	0.100	1.6	3.2	0.140	0.330
2006	0.8	2.0	0.100	0.100	1.8	3.4	0.110	0.220
2007	0.8	2.0	0.030	0.060	1.6	2.5	0.140	0.670
2008	0.7	1.0	0.030	0.030	1.5	2.3	0.060	0.160
2009	0.7	1.0	0.025	0.030	1.6	3.0	0.050	0.140
2010	0.9	2.0	0.025	0.030	1.8	3.6	0.060	0.180
2011	1.0	1.0	0.025	0.030	1.5	2.2	0.120	0.320
2012	0.5	1.5	0.025	0.030	1.6	2.7	0.070	0.280

*Data provided by Mike Aziz, Goldcorp Canada.

Water flow

An overall trend in declining discharge volume for the Upper Bulkley River is evident. Specifically, flow rate in the Bulkley River at Quick during the August-September period when sockeye migrate into the sub-basin declined significantly during 1931-2011 (R^2 = 0.090, df = 79, p = 0.006; Figure 10). Flow rate during the August-September period measured at the Bulkley River at Houston also declined during 1931-2011, though the results are not statistically significant (R^2 = 0.017, df = 30, p = 0.481), and are likely influenced by the low sample size. The recent trend in declining discharge volumes corresponds to a period since 1976 during which the regional October to April precipitation has been generally 7-10% below the long-term mean. A similar climate trend has been observed in south-central BC and throughout the Canadian prairies, suggesting that reduced precipitation is likely at least partly driving the decline in flow for the Upper Bulkley River.

Removal of riparian forests may also contribute to reduced water flow in the Upper Bulkley River. Land-use activities for timber, agriculture, and linear development, particularly on the Bulkley River mainstem, have resulted in the complete removal, or alteration, of much forested riparian habitat (MacKay et al. 1998). One consequence of such activities is ground compaction, whereby the snowpack generally melts more quickly, increasing peak flows, and resulting in less water in the system over time.

Licenced water withdrawals for agriculture and human use may further play a role in decreased water flow. The last report on licenced water withdrawal in the Upper Bulkley was 0.527 m^3/s (Brocklehurst 1998), which is more than double the average 7-day, 10-year, low flow of 0.216 m^3/s derived from the 1980-1993 Water Survey of Canada April-September data (Remington 1996; Gottesfeld and Rabnett 2008). Most water withdrawals for irrigation in the Upper Bulkley valley are from small tributary streams, which are not gauged, and thus it is difficult to determine actual usage. Therefore, the installation of gauges at all locations of water withdrawals would help to accurately assess whether such withdrawals are a significant factor in relation to low flows.

Introduced species

The dominant human activity occurring today along the Upper Bulkley River is agriculture, particularly in the form of hayfields grown for livestock. Much riparian forest habitat has been removed, with hayfields commonly extending to the river bank. Beyond the direct issue of riparian forest removal is the establishment and persistence of non-native grasses where once native low-lying riparian vegetation occurred (Figure 11). In some areas, such as the riparian habitat immediately downstream of Bulkley Lake, these non-native grasses form dense aggregations that effectively exclude all other flora. To what degree such a shift in terrestrial plant species may affect the overall riparian community assemblage is unknown, but it is likely that some forms of fauna (particularly terrestrial insects) have been reduced in abundance and/or displaced along the river banks where such exotic species are aggregated. In terms of habitat recovery, removal of non-native grasses in favour of a return to native species may be a very difficult task.

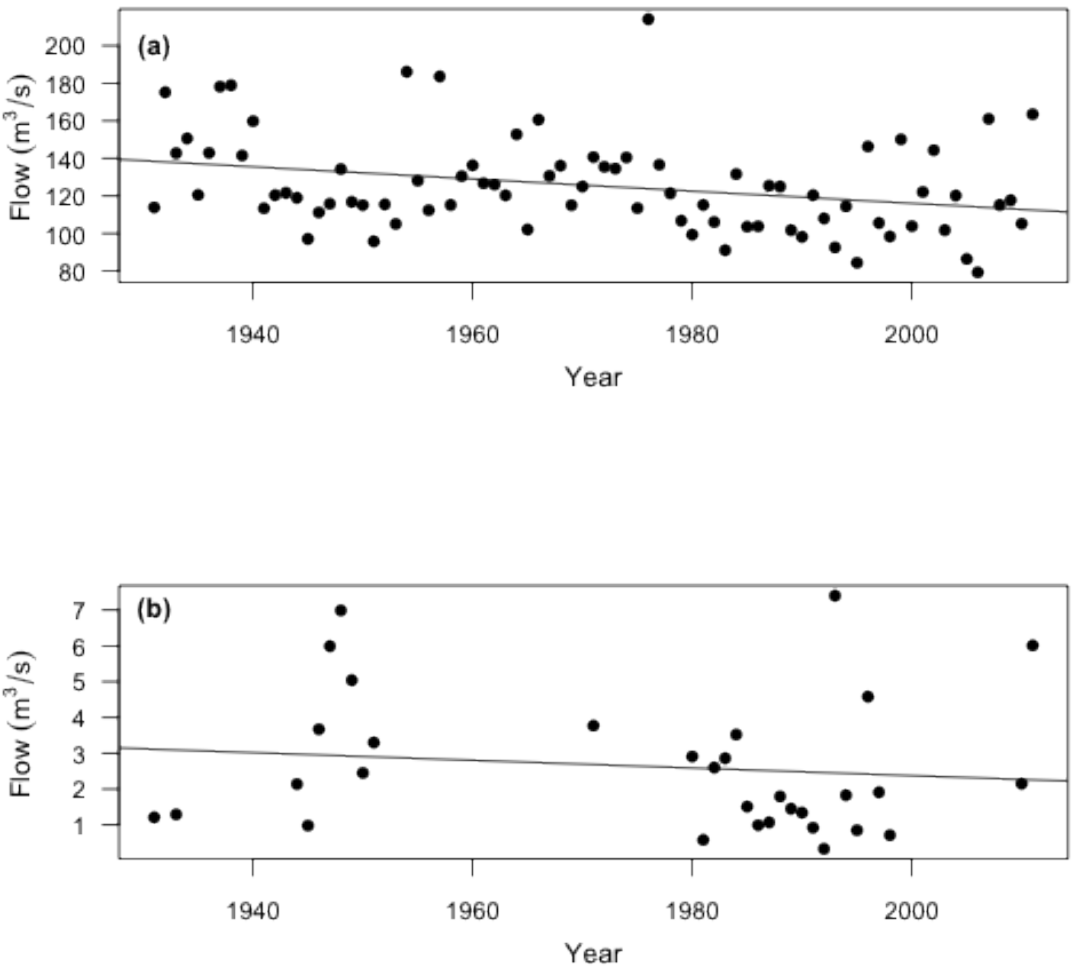

Figure 10. Discharge volumes for the Upper Bulkley River recorded at Quick (a) and Houston (b) hydrometric stations during the August-September period of 1931-2011. Declining trend in flow is significant at Quick ($R^2 = 0.090$, df = 79, $p = 0.006$), but not at Houston ($R^2 = 0.017$, df = 30, $p = 0.481$).

Figure 11. Introduced grasses displace native riparian vegetation along most sections of the Upper Bulkley River where hayfields are located adjacent to the river bank, April 2013. Photo: Michael Price.

2. Groundwater Influence

It is becoming more widely recognized that spawning salmon utilize areas of river channel where there is continuous flow between surface water and groundwater. Such locations may be observed in the winter as sites of open water. During a single helicopter flight on February 20, 2014 (see: Upper_Bulkley_Flight_20Feb14.kml file for full details of flight path and waypoints of interest), we observed 57 areas of open water (recorded in 92 photographs; images provided on Disk-2) on the Upper Bulkley River between Houston and Maxan Lake that may indicate areas of groundwater influence (Table 6; Figures 12 and 13). The areas of most significant open water included the outlet of Bulkley Lake, the confluence of Maxan Creek and Foxy Creek, and outlet of Maxan Lake (Upwelling waypoints 81 and 94). Temperature on the day of flight ranged 0 to -5 ^{o}C; the previous week temperature ranged +4 to -11. Several areas showed heavy wildlife usage, including moose, deer, beaver, fox, and several bird species. During our initial habitat survey of the Upper Bulkley River on October 28, 2013, we observed adult salmon at 5 separate locations (Habitat waypoints: 126, 137, 138, 159, 205; Appendix 1); all of which were downstream of Bulkley Falls. Two locations where we observed salmon were within close proximity to open water (Groundwater waypoints: 63 and 71).

Relevance to sockeye salmon

Sockeye salmon (*Oncorhynchus nerka*) arguably are one of the most threatened species in the Upper Bulkley (Gottesfeld and Rabnett 2008). Traditional locations of Wet'suwet'en sockeye fisheries in the Upper Bulkley catchment include: Maxan Lake outlet (Tasdleegh), confluence of Maxan Creek and Foxy Creek (Tsaslachque), Bulkley Lake outlet (Nehl' dzee tez diee), and Bulkley Falls (Gottesfeld and Rabnett 2008). The earliest records of sockeye in the Upper Bulkley by fisheries officers date back to August 10, 1939, when the run was considered "Medium heavy, favorable" (BC 16 Reports). On August 20 of the following year, 1940, a fishery officer reported "Fairly heavy, not quite as heavy as 1936".

Enumeration of sockeye in the Upper Bulkley by fisheries officers was most intense during the 1960s and 1970s, with spawner counts ranging 50-600 (Table 7). Enumeration effort declined substantially throughout the 1980s (3 count-years), to the most recent single count observed in 1995. Within DFO's current NuSEDS database, Upper Bulkley sockeye are divided into Maxan and Upper Bulkley stocks, which represent Lake-type and River-type CUs, respectively (Table 8). It is important to note that there are several discrepancies between data in NuSEDS and the historical fishery reports. For example, fishery records for the period 1960-1964 record the presence of sockeye between Bulkley Lake and Maxan Lake; yet, NuSEDS include these records as Upper Bulkley (not Maxan). A similar discrepancy exists for the years 1973-1976 and 1978.

Results from linear regression analysis show a significant downward trend in spawner escapement over time for Upper Bulkley sockeye ($R^2 = 0.250$, df = 17, $p = 0.029$; Figure 14). However, this trend is confounded by the recent decline in monitoring effort, shown in the low spawner counts beginning in 1983 when sockeye were counted through the fence at Houston in September (i.e., no August counts when sockeye would have been actively migrating upstream if water conditions were suitable).

Table 6. Locations of open water recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, during a helicopter flight on February 20, 2014. Waypoint number refers to locations plotted in: Upper_Bulkley_Flight_20Feb14.kml.

Waypoint number	Photo series	Easting	Northing	Notes
32	UB_UP-1	652874	6030936	Open water
33	UB_UP-2	654057	6031887	Wildlife usage
34	UB_UP-3	655302	6032933	Open water
35	UB_UP-4 to 5	655527	6033173	Open water
36	UB_UP-6	655239	6033540	Open water
37	UB_UP-7	655837	6033943	Wildlife usage
38	UB_UP-8	655901	6034120	Wildlife ueage
39	UB_UP-9	655977	6034692	Open water
40	UB_UP-10	656592	6034857	Open water
41	UB_UP-11 to 12	656413	6035077	Open water
42	UB_UP-13 to 14	656972	6035284	Open water
43	UB_UP-15	657195	6035406	Fox
44	UB_UP-16 to 19	658039	6035552	Open water
45	UB_UP-20	658281	6036172	Open water
46	UB_UP-21	658766	6035853	Open water
47	UB_UP-22 to 23	658969	6035925	Open water
48	UB_UP-24 to 25	659591	6036494	Open water
49	UB_UP-26	660141	6037030	Open water
50	UB_UP-27	660491	6037195	Open water
51	UB_UP-28	660884	6037609	Open water
52	UB_UP-29	661000	6037640	Open water
53	UB_UP-30	661084	6038071	Open water
54	UB_UP-31	661657	6038480	Open water
55	UB_UP-32	662466	6038560	Open water
56	UB_UP-33 to 34	662969	6039283	Open water
57	UB_UP-35	662770	6040498	Open water
58	UB_UP-36	663065	6041249	Open water
59	UB_UP-37 to 38	663236	6041845	Open water
60	UB_UP-39	664145	6043416	Open water
61	UB_UP-40	665073	6043567	Open water
62	UB_UP-41	665589	6043674	Open water
63	UB_UP-42	667707	6043734	Open water
64	UB_UP-43	668065	6044066	Open water and wildlife usage
65	UB_UP-44 to 45	668353	6043977	Open water and wildlife usage
66	UB_UP-46	669392	6043876	Open water
67	UB_UP-47 to 48	670022	6043931	Open water and wildlife usage
68	UB_UP-49 to 50	670419	6043610	Open water and wildlife usage
69	UB_UP-51	671823	6043132	Open water
70	UB_UP-52	673717	6042977	Open water
71	UB_UP-53	677607	6040661	Open water
72	UB_UP-54	679277	6037245	Wildlife usage
73	UB_UP-55	681292	6035587	Wildlife usage
74	UB_UP-56	680971	6035236	Open water
75	UB_UP-57	681560	6032678	Open water and wildlife usage
76	UB_UP-58	682814	6032103	Open water and wildlife usage
77	UB_UP-59 to 61	683498	6032079	Open water and wildlife usage
78	UB_UP-62	683901	6031712	Open water
79	UB_UP-63 to 64	684151	6031411	Open water
80	UB_UP-65	684590	6031212	Open water
81	UB_UP-66 to 70	685825	6030250	Open water at Bulkley Lake outlet
82	UB_UP-71	686542	6029900	Open water at Maxan Ck outlet
83	UB_UP-72 to 73	685720	6029260	Open water
84	UB_UP-74 to 75	685660	6028912	Open water
85	UB_UP-76 to 77	685355	6028750	Open water and wildlife usage
86	UB_UP-78 to 79	684039	6027977	Open water and wildlife usage
87	UB_UP-80	683768	6026804	Open water and wildlife usage
88	UB_UP-81	684873	6024844	Open water
89	UB_UP-82	685395	6024653	Open water
90	UB_UP-83	685856	6024441	Open water
91	UB_UP-84	686026	6024197	Open water
92	UB_UP-85	686453	6023845	Open water
93	UB_UP-86	687491	6022965	Open water
94	UB_UP-87 to 92	686504	6023885	Open water at Foxy confluence and approach to Maxan Lake

Figures 12 and 13. Locations of open water (potential areas of groundwater intrusion) recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, February 2014. Photos: Brian Huntington.

Table 7. Enumeration records and fishery officer observation notes for sockeye salmon counted in the Upper Bulkley catchment for the period 1960-1995. [] is concentration of fish.

Year	Number	Observation dates	Notes
1960	Present	Aug 18-Sept 10	To Maxan Lake outlet
1962	400	Aug 15-Sept 10	To Maxan Lake
1963	600	Aug 10-Sept 10	To Maxan Creek entrance
1964	300	Aug 10-Sept 15	To Bulkley Lake
1965	100	Aug 1-Aug 30	
1970	50	Aug-Sept	
1972	300	September	
1973	300	Aug-Sept	To Maxan Lake ([] at Foxy Creek)
1974	200	Aug-Sept	To Maxan Lake
1975	64	Aug-Sept	Bulkley Lake outlet (possibly Maxan)
1976	Present	Aug-Sept	To Maxan Lake ([] at Foxy Creek)
1977	200	Aug-Sept	To Maxan Lake
1978	50	Aug-Sept	To Maxan Lake
1979	600		Below Bulkley Lake
1983	25	On August 19	At Houston counting fence
1987	12	Sept 4-30	At Houston counting fence
1989	9	Sept 13-30	At Houston counting fence
1995	20	Sept 2-Nov 2	At Houston counting fence

Table 8. Enumeration records in DFO's NuSEDS database for escapement counts (Number) of sockeye salmon from Maxan and Upper Bulkley Conservation Units.

Population	Year	Number
Maxan	1969	200
	1971	300
	1977	100
Upper Bulkley	1960	200
	1962	400
	1963	600
	1964	300
	1965	100
	1970	50
	1972	300
	1973	300
	1974	200
	1975	64
	1977	200
	1978	50
	1979	600
	1983	25
	1987	12
	1989	9
	1995	20

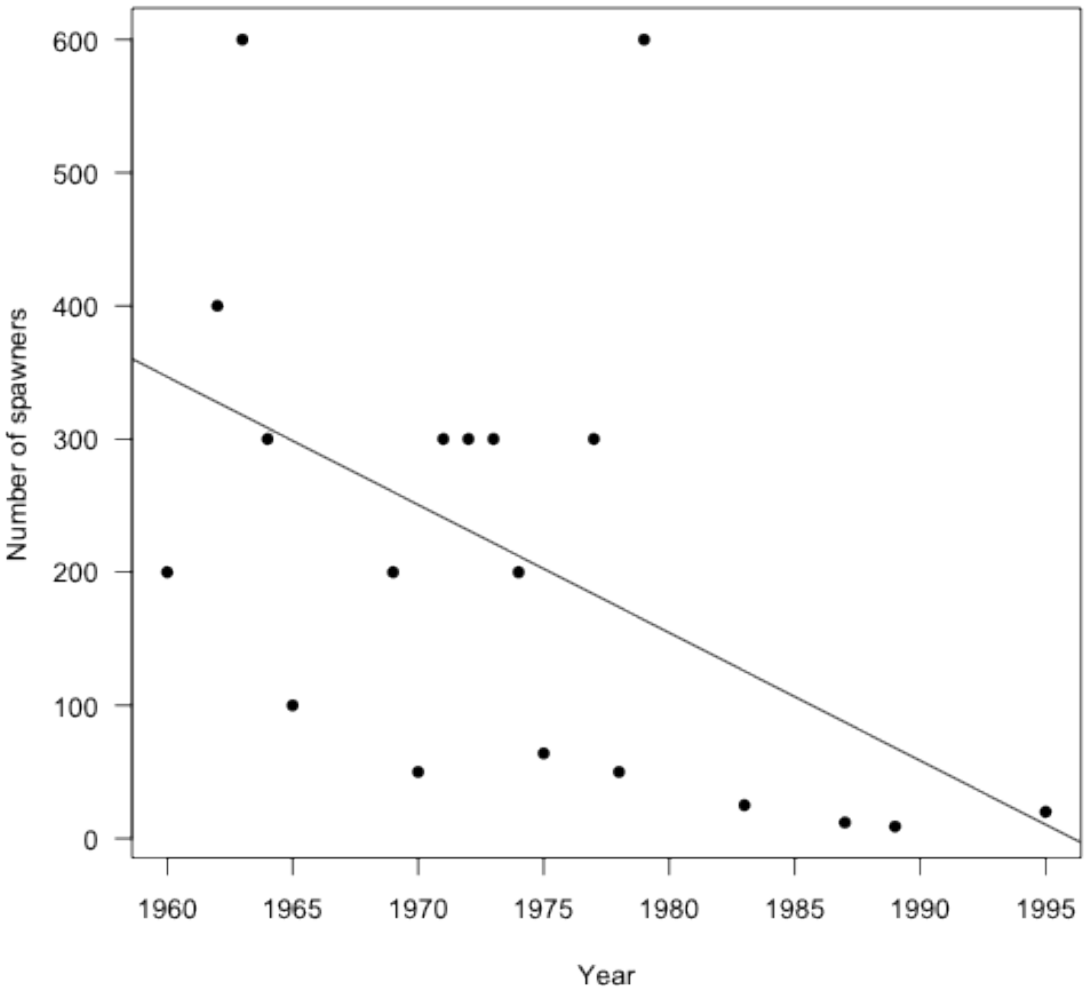

Figure 14. Trend in the number of sockeye salmon spawners counted in the Upper Bulkley catchment since 1960. Regression analysis showed a significant declining trend over time ($R^2 = 0.250$, df = 17, $p = 0.029$).

Of the locations traditionally important to sockeye spawning, 3 of the 4 sites (Maxan Lake outlet, confluence of Maxan Creek and Foxy Creek, and outlet of Bulkley Lake) showed considerable open water, likely from the influence of groundwater. Habitat has been most significantly modified at the outlet of Bulkley Lake, where riparian forests have long-been removed, railway infrastructure in the form of a bridge and rail-line persist, as does a secondary gravel road and private bridge, homestead with associated outbuildings and livestock, and hayfields border the Bulkley River and Bulkley Lake. The confluence of Foxy Creek and Maxan Creek appears in good physical condition, although the concentrations of some heavy metals (such as copper) discharged from the Equity Silver mine likely has had some impact on fish at this location in the past. There currently is one beaver dam at the Maxan Lake outlet, and an occupied beaver lodge, which does not appear to be a major barrier to sockeye. However, flow in Maxan Creek is considered a potential concern, and an active beaver dam may reduce flow sufficiently during summer months when spawning fish need it most. Finally, Bulkley Falls may be a primary barrier to many returning adult salmonids during low flow seasons and years, as flow in the Upper Bulkley during the time of adult sockeye migration is now significantly less than it was decades ago.

The recent habitat report cards produced by the Pacific Salmon Foundation and ESSA Technologies for the lake-sockeye Conservation Units of Bulkley (http://skeenasalmonprogram.ca/library/lib_286/) and Maxan (http://skeenasalmonprogram.ca/library/lib_298/) show that fish are subject to high cumulative pressures during their migration, spawning, and rearing life-stages in the Upper Bulkley sub-basin. The indicators used to assess pressures on spawning and rearing habitat included: forest disturbance, riparian disturbance, road development, stream crossing density, water licences, linear development, and permitted waste-water discharge and acid generation from metal mine activity. This report helps improve the resolution regarding riparian disturbance, road development, and barriers to fish passage, but it is important to recognize that many other habitat disturbances have occurred, and their subsequent effect on fish may persist.

Several market access energy projects have been proposed for the Upper Bulkley sub-basin. Enbridge Northern Gateway proposes to transport raw bitumen from Alberta to Kitimat, and condensate from Kitimat to Alberta, in twinned pipelines that will cross Maxan and Foxy Creeks, as well as the upper Buck drainage. Currently, the PNG/AltaGas natural gas pipeline crosses Maxan Creek and the Bulkley River mainstem. Several natural gas pipelines are proposed, including the Pacific Trails Pipeline (PTP), the Coastal GasLink (CGL), and the Pacific Northern Gas Looping (PNGL) project. The Pacific Trails Pipeline and CGL propose to cross the upper Maxan and Buck Creeks. The PNGL is proposed to be located adjacent to the current PNG/AltaGas pipeline. These proposed projects are anticipated to degrade salmon habitat during the development, operation, and closure phases.

Either of the two locations (Groundwater waypoints: 63 and 71) downstream of Bulkley Falls where we observed salmon during our Autumn habitat survey, and recorded open water during our winter flight, may be important habitat for river-type sockeye, or other

species, which are thought to persist in the Upper Bulkley, particularly in low flow years. And I recommend that these sites be the focus of future enumeration surveys. Certainly, enumeration effort for sockeye returning to the Upper Bulkley has been poor, to non-existent, since 1980, and this needs to drastically improve.

Closing Statement

The aforementioned assessment was undertaken to document human-induced modifications to floodplain habitat and river channelization, potential barriers to fish migration, and areas of upwelling in the Upper Bulkley sub-basin that have potential importance to salmonids. We observed and recorded a total of 131 separate habitat concerns during a helicopter flight on October 28, 2014. Modifications to habitat associated with transportation infrastructure (railway and roads, which included crossings; 50) were the most frequently observed habitat concern, followed by riparian habitat loss (41), beaver activity (29), log-jam (10), cattle on river bank (2), and land slide (1).

During a separate helicopter flight on February 20, 2014, we observed 57 locations of open water on the Upper Bulkley River upstream of Morice River to the headwaters at Maxan Lake, which may indicate areas of groundwater intrusion. Importantly, the traditional Wet'suwet'en harvest sites for sockeye at the outlet of Maxan Lake, the confluence of Foxy Creek and Maxan Creek, and the outlet of Bulkley Lake, all showed signs of groundwater intrusion, which helps support our understanding that these habitats are favourable to salmonids. Habitat has been significantly modified at the outlet of Bulkley Lake, where riparian forests have long-been removed, railway infrastructure and secondary gravel roads persist, a homestead with associated outbuildings and livestock are positioned directly adjacent to the river, and hayfields border the Bulkley River and Bukley Lake.

While the Bulkley River upstream of Morice River has some of the most intense public and private land use in the Skeena watershed, it is of high value to salmonids. Two locations downstream of Bulkley Falls where we observed salmon during our initial habitat survey were within close proximity to open water sections, and I recommend that these areas (in addition to the historical sockeye spawning and Wet'suwet'en harvesting locations: Bulkley Lake outlet, confluence of Maxan and Foxy Creeks, and Maxan Lake outlet) be the primary focus of future enumeration surveys for sockeye and other salmonids. We are grateful to Fisheries and Oceans for their timely funding and support for this important initiative, and hope the information acquired can be used towards recovery plans for diminished fish species, such as sockeye.

Recommendations

- Renewed enumeration effort for adult sockeye spawning in the section from the Upper Bulkley River (at Bulkley Lake outflow, confluence of Foxy Creek and Maxan Creek, and Maxan Lake outflow). Additionally, there are historical and recent reports of sockeye spawning on the east shore of Maxan Lake, and attempts should be made to verify and count lake spawners.

- Initiation of a sockeye fry and/or smolt capture program in Bulkley and Maxan Lakes to acquire baseline genetic data, confirmation of lake rearing behaviour, age structure, health, and abundance.

- Quantification of floodplain habitat loss in the Upper Bulkley sub-basin due to railway and road infrastructure.

- Initiation of a water monitoring program to quantify the actual amounts of water withdrawn by licensees in the upper Bulkley catchment during the April to September low-flow period.

- Assessment of the in-stream flow requirements for sockeye and other salmonids to ascend Bulkley Falls during spawning migration.

- Initiation of a water quality monitoring program for Bulkley and Maxan Lakes. A detailed assessment might include: nutrient levels (are BC provincial water quality guidelines for spring overturn total phosphorus still exceeded in Bulkley Lake?), temperature during spawning migration, and dissolved oxygen.

- If current water quality is determined poor, an assessment of the local influence of agriculture (particularly cattle ranching) is recommended. Particular issues of interest are: release of silage effluent and wasted feed, manure handling and/or storage, yard run-off from outdoor cattle pens in proximity of watercourses, improper cattle watering facilities with direct access to water courses, and leachate production from sawdust storage.

- A renewed assessment of contaminated soils at the Richfield Loop concentrate shed site adjacent to the upper Bulkley River near Topley to determine whether water quality and associated aquatic life are receiving significant impacts from past deposits of copper sulphide concentrates.

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Appendix 1. Human induced habitat modifications recorded on the Bulkley River upstream of Morice River to the headwaters at Maxan Lake, during a helicopter flight on October 28, 2013. Waypoint number refers to locations plotted in: Upper_Bulkley_Flight_28Oct13.kml.

Waypoint number	Photo series	Time	Easting	Northing	Notes
34	UB-1 to 5	12:17:24	651142	6029782	Helicopter hanger
35	UB-6	12:17:35	651145	6029783	Above hanger
36	UB-7 to 11	13:13:51	655753	6034037	Upstream floodplain
37	UB-12 to 25	13:14:15	656263	6034756	Floodplain/railway
38	UB-26 to 40	13:14:36	656802	6035246	Disconnected floodplain
39	UB-41 to 56	13:16:07	659412	6036188	Riparian loss - Field to river
40	UB-57 to 58	13:16:43	660202	6036794	Forest removal - slash piles
41	UB-59 to 64	13:17:16	660839	6037624	Disconnected floodplain
42	UB-65 to 74	13:17:51	661597	6038300	Cattle farm
43	UB-75 to 81	13:19:00	662959	6039601	Hay field
44	UB-82 to 88	13:19:37	662892	6040706	Floodplain loss to Hwy/rail
45	UB-89 to 91	13:20:36	663515	6042344	Backchannel cutoff
46	UB-92 to 93	13:21:19	664256	6043397	Hay field
47	UB-94 to 103	13:22:29	666027	6043735	Hay field
48	UB-104 to 106	13:23:10	667123	6043706	Floodplain loss to rail
49	UB-107	13:24:06	668607	6043932	Rail impediment at Oxbows
50	UB-107	13:24:52	669825	6044009	Rail crossing
51	UB-108	13:25:17	670482	6043704	Floodplain loss to rail
52	UB-109 to 120	13:26:15	672259	6043155	Backchannel cutoff by rail, f
53	UB-121	13:27:10	674085	6042903	Topley rail crossing
54	UB-122 to 132	13:27:43	674810	6042145	Field to river
55	UB-133 to 142	13:28:26	675972	6042137	Floodplain loss to rail
56	UB-143 to 144	13:28:54	676499	6041543	Floodplain loss to rail
57	UB-145 to 153	13:29:34	677448	6040835	Floodplain loss to rail
58	UB-154 to 164	13:30:40	677958	6038866	New rail double track
59	UB-165 to 169	13:31:51	679597	6037220	Rail crossing
60	UB-170 to 174	13:32:21	680465	6036862	Hay fields
61	UB-175	13:33:21	681046	6035306	Clearcut
62	UB-176 to 182	13:34:12	680961	6033872	Intact section
63	UB-183 to 194	13:34:47	681638	6032905	Forestdale road
64	UB-195 to 199	13:35:40	683201	6032161	Straumbold farm downstrear
65	UB-200 to 211	13:37:05	685413	6030472	Bulkley Lake outlet
66	UB-212 to 223	13:38:29	686021	6029364	Hay field to maxan
67	UB-224 to 227	13:40:26	683888	6026908	maxan cutblock
68	UB-228 to 231	13:41:16	683875	6025320	maxan cutblock

69	UB-232	13:42:03	684994	6024684	hay field to maxan
70	UB-233	13:42:53	686279	6024057	road crossing
71	UB-234 to 236	13:44:41	687177	6023224	Maxan lake
72	UB-237 to 241	13:45:09	686813	6022650	Foxy creek cutblock
73	UB-242 to 245	13:47:37	686860	6022124	Foxy creek cutblock
74	UB-239 to 256	13:48:44	686992	6023133	foxy/maxan confluence
75	UB-257	13:49:59	686614	6023770	road crossing
76	UB-258	13:50:32	686210	6024130	hay field to creek
77	UB-259 to 261	13:51:59	685466	6024649	maxan beaver dam
78	UB-262 to 264	13:53:09	685237	6024844	field to river-log jam
79	UB-265 to 270	13:54:18	684348	6024997	Beaver dam
80	UB-271 to 274	13:56:04	683932	6026032	beaver dam/breach
81	UB-275 to 282	13:57:42	683762	6026942	land slide
82	UB-283 to 285	13:59:09	683917	6027487	hay field / jam
83	UB-286 to 290	13:59:45	684190	6027906	Beaver activity
84	UB-291 to 299	14:00:19	684354	6028189	Hay field
85	UB-300 to 304	14:01:09	684890	6028667	Beaver activity
86	UB-305 to 307	14:01:28	685106	6028665	Beaver dam
87	UB-308 to 314	14:02:05	685428	6028712	Beaver dam
88	UB-315 to 321	14:02:27	685549	6028826	derelict bridge
89	UB-322 to 324	14:03:09	685814	6029114	Beaver dam
90	UB-325 to 327	14:03:35	685789	6029396	Hay field to maxan
91	UB-328 to 334	14:03:53	686037	6029429	Hay field to maxan
92	UB-335 to 338	14:04:27	686479	6029579	Maxan Lake outlet
93	UB-339 to 341	14:05:35	686187	6030211	Bulkley Lake outlet
94	UB-342 to 356	14:06:06	685785	6030439	Strombould's rail/road crossi
95	UB-357 to 362	14:06:37	685310	6030510	rip-rap
96	UB-363 to 365	14:07:18	685110	6030621	Field to river
97	UB-366 to 369	14:07:47	684926	6031060	rip-rap
98	UB-370 to 372	14:08:57	684495	6031282	Field to river
99	UB-373 to 383	14:09:47	684008	6031695	Beaver dam/field to river
100	UB-384 to 388	14:10:33	683685	6032076	bridge/hay field
101	UB-389 to 395	14:11:22	683002	6032245	rail bridge
102	UB-396 to 402	14:12:12	682505	6032418	Rail impediment
103	UB-403 to 405	14:12:57	682091	6032534	bridge crossing
104	UB-406 to 410	14:13:36	681888	6032762	bridge crossing
105	UB-411 to 412	14:14:31	681419	6033019	beaver dam
106	UB-413 to 415	14:15:02	681137	6033505	beaver dam
107	UB-416	14:15:19	681166	6033765	beaver dam
108	UB-417	14:16:11	680743	6034552	beaver dam
109	UB-418	14:16:37	680933	6034871	beaver dam
110	UB-419 to 424	14:17:26	681055	6035312	beaver dam/rail bridge
111	UB-425	14:18:15	681362	6035812	Hayfield/power line

112	UB-426 to 427	14:18:44	681042	6036271	rail/rip-rap
113	UB-428 to 430	14:19:08	680861	6036661	hay field to creek
114	UB-431 to 434	14:19:51	680310	6037029	bridge
115	UB-435 to 440	14:20:20	679974	6037284	beaver dam
116	UB-441 to 444	14:20:49	679961	6037252	bridge and new track
117	UB-445	14:21:22	679540	6037279	Beaver dam
118	UB-446 to 448	14:21:51	679148	6037507	Beaver dam/rail to river
119	UB-449 to 453	14:22:17	679010	6037815	Beaver dam
120	UB-454 to 455	14:22:39	678774	6038004	Beaver dam
121	UB-456 to 459	14:23:20	678295	6038283	Bulkley falls
122	UB-460 to 462	14:24:01	678222	6038509	Beaver dam
123	UB-463 to 464	14:24:19	678184	6038767	Log jam
124	UB-465 to 466	14:24:37	678104	6039025	Beaver dam
125	UB-467	14:25:23	677952	6039499	Hay field
126	UB-468 to 471	14:25:44	677719	6039669	Beaver dam/Spawners
127	UB-472	14:26:26	677666	6039852	Beaver dam
128	UB-473 to 475	14:26:38	677550	6039878	Beaver dam
129	UB-476 to 479	14:27:09	677763	6040152	Rail crossing
130	UB-480 to 486	14:27:39	677719	6040526	rip-rap/beaver dam
131	UB-487 to 488	14:28:17	677614	6040916	field to river
132	UB-489 to 492	14:28:33	677292	6040997	Rail crossing
133	UB-493	14:29:02	676911	6041236	beaver dam
134	UB-494 to 496	14:29:13	676801	6041386	rip-rap/beaver dam
135	UB-497 to 501	14:29:40	676547	6041728	rail to river
136	UB-502 to 507	14:30:04	676358	6042030	rail to river
137	UB-508 to 509	14:30:43	675666	6041986	Spawning salmon
138	UB-510 to 511	14:31:12	675177	6042050	field to river/spawners
139	UB-512	14:31:35	674850	6042113	cattle farm to river
140	UB-513 to 515	14:32:10	674572	6042590	field to river
141	UB-516 to 522	14:32:21	674492	6042716	Topley crossing
142	UB-523	14:33:36	673931	6043020	rail to river
143	UB-524 to 526	14:33:48	673672	6043081	field to river
144	UB-527 to 532b	14:34:13	673142	6043205	Rail impediment
145	UB-533 to 534	14:35:18	671960	6043267	ploughed field to river
146	UB-535 to 536	14:36:48	672014	6043155	Richfield confluence
147	UB-537 to 538	14:37:06	672098	6043368	rail bridge/richfield
148	UB 539	14:37:27	672217	6043636	Homested on river bank
149	UB-539a	14:37:43	672332	6043861	Richfield village
150	UB-540 to 545	14:38:01	672459	6044122	Culvert on Richfield creek
151	UB-546 to 548	14:40:55	670206	6043943	rail bridge
152	UB-549 to 555	14:41:20	670218	6044233	Johnny-David confluence/fie
153	UB-556 to 558	14:42:01	670260	6044784	Johnny_David Hwy culvert
154	UB-559 to 561	14:43:22	669614	6044178	Log jam on Bulkley

155	UB-562 to 563	14:43:41	669392	6043980	rail to river
156	UB-564 to 566	14:44:09	668935	6043858	rip-rap and rail impediment
157	UB-567 to 568	14:44:38	668718	6044141	field to river
158	UB-569 to 570	14:45:13	668132	6044225	field to river
159	UB-571 to 576	14:45:35	667876	6044164	rail bridge/spawners
160	UB-577 to 580	14:46:02	667599	6043901	rail to river
161	UB-581 to 584	14:46:46	666827	6043710	field to river
162	UB-585 to 586	14:47:04	666637	6044012	field to river
163	UB-587 to 588	14:47:58	665701	6043914	Byman Ck rail bridge
164		14:48:29	665847	6044090	Byman Ck Hwy bridge?
165	UB-589 to 595	14:49:12	666717	6044190	Byman Ck Hwy culvert
166		14:50:41	665631	6043933	Perow Ck?
167	UB-596 to 597	14:50:56	665378	6043809	Byman/Perow Ck confluenc
168	UB-598 to 600	14:51:14	665013	6043738	field to river
169	UB-601 to 608	14:51:49	664394	6043652	McQuarrie Ck rail bridge
170	UB-609 to 610	14:52:45	663942	6043256	Rail impediment
171	UB-611 to 612	14:53:44	663396	6042264	Rail impediment
172	UB-613 to 616	14:54:40	662962	6041236	Rail impediment
173	UB-617 to 623	14:55:17	662763	6040601	field to river
174	UB-624 to 625	14:55:41	662902	6040258	Log jam
175	UB-626 to 627	14:56:10	663203	6039849	field to river
176	UB-628 to 630	14:56:39	662888	6039572	cattle on river bank
177	UB-631	14:57:27	662554	6038924	field to river
178	UB-632	14:58:08	661935	6038530	field to river
179	UB-633	14:58:24	661750	6038638	field to river
180	UB-634 to 639	14:59:00	661181	6038563	Rail impediment
181	UB-640 to 642	14:59:26	661220	6038243	field to river
182	UB-643 to 645 [UB-645b]	15:00:28	661095	6037670	field to river
183	UB-646 to 649	15:00:46	660929	6037901	Rail impediment
184		15:01:16	660629	6037716	Rail impediment
185	UB-650 to 651	15:01:28	660804	6037542	field to river
186	UB-652 to 653	15:02:22	660186	6037094	field to river/new felling
187	UB-654	15:02:38	659934	6037048	Log jam
188	UB-655	15:02:51	660025	6036894	field to river
189	UB-656 to 659	15:03:12	659727	6036905	Beaver dam
190	UB-660 to 662	15:03:34	659600	6036720	Rail impediment
191	UB-663	15:04:04	659158	6036486	Rail impediment
192	UB-664 to 667	15:04:16	658950	6036296	field to river
193	UB-668	15:04:59	658767	6036267	Rail impediment
194	UB-669 to 671	15:05:12	658629	6036169	Rail impediment
195	UB-672	15:05:53	658302	6035960	field to river/new felling
196	UB-673	15:06:18	658300	6035785	Bridge crossing

197	UB-674	15:07:22	656975	6035591	Rail impediment
198	UB-675 to 677	15:08:06	656590	6035193	Rail impediment
199	UB-678 to 683	15:08:50	656233	6034772	Rail impediment
200	UB-684 to 687	15:09:29	655751	6034399	Log jam/rail impediment
201	UB-688	15:10:26	655269	6033756	Log jam
202	UB-689	15:10:55	655385	6033514	Log jam
203	UB-690 to 692	15:12:26	654578	6032198	field to river
204	UB-693 to 694	15:12:46	654145	6032016	field to river
205	UB-695 to 698	15:13:08	653873	6031629	cows to river/salmon/road in
206	UB-699 to 704	15:13:29	653536	6031438	bridge, road impediment
207	UB-705 to 706	15:14:10	653033	6031247	Houston bridge
208	UB-707 to 708	15:14:47	652529	6031048	Houston rip-rap
209	UB-709 to 712	15:15:32	651559	6030710	Houston rip-rap
210	UB-713 to 715	15:15:58	651100	6030372	Houston settling ponds
211	UB-716	15:16:14	651063	6030024	Westland rip-rap
212	UB-717 to 719	15:16:47	650701	6029641	rail rip-rap